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ABSTRACT

In this document, a description is given of a one activity inservice session intended for teachers kindergarten through grade six. The objective of this activity is to identify the launch angle of a catapult as the variable controlling the distance a projectile will travel. The activity conducted by participants of this workshop deals with the process of science, and is carried out by the participants exactly as their students would be expected to conduct it. Emphasized in the workshop are cooperative learning techniques, data gathering, data pooling, and other processes used in the field by practicing scientists as they attempt to learn something about previously unknown or little understood phenomena. The activity also includes a computer component. The activity includes: the science concept; objective; grade levels; time requirements; partial list of variables; science, math, and computer skills; vocabulary; materials; procedures; and curriculum extensions. (KR)

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HANDS-ON SCIENCE WORKSHOP "CONTROLLING VARIABLES" SEOUL AM ES FALL 1990

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INTRODUCTION

"Controlling Variables" is a one activity inservice session intended for teachers kindergarten through grade six. The activity conducted by participants of this workshop deals with the process of science, and is carried out by the participants exactly as their students would be expected to conduct it. The workshop has, built into it, cooperative learning techniques, data gathering, data pooling and other processes used in the field by practicing scientists as they attempt to learn something about previously unknown or little understood phenomena. The activity also includes a computer component.

DATA GATHERING WORKSHEET
FOR INSERVICE USE ONLY

Team	Trial Number	Projectile Mass	Launch Angle	Projectile TVL Dist.	Length Cat. Arm	Dist. FM Floor	Others

Isolating the Controlling Variable in Elementary School Science With a Catapult

Richard M. Schlenker
Regional Office

Mark R. Malone
University of Colorado

Sarah J. Yoshida
Seoul American Elementary School

INTRODUCTION

Studying science as a process often involves attempts to isolate variables controlling a phenomenon. The isolation of controlling variables allows investigators to establish cause-effect relationships or sequences. Students who participate in this activity do both. They study as a process and attempt to establish cause-effect relationships. Mark R. Malone, University of Colorado at Colorado Springs, architect of the activity from which this activity was derived used a marshmallow catapult to help students study the process. He used marshmallows because their size to mass ratio is low, insuring that if a catapulted marshmallow struck a student, the student would not be injured. In addition, if a marshmallow was to strike a classroom window or some other fragile classroom fixture, neither would be damaged.

To review, catapults are a modification of a first class lever. They were used to hurl objects a long distance (see Figure 1). Thus it was,

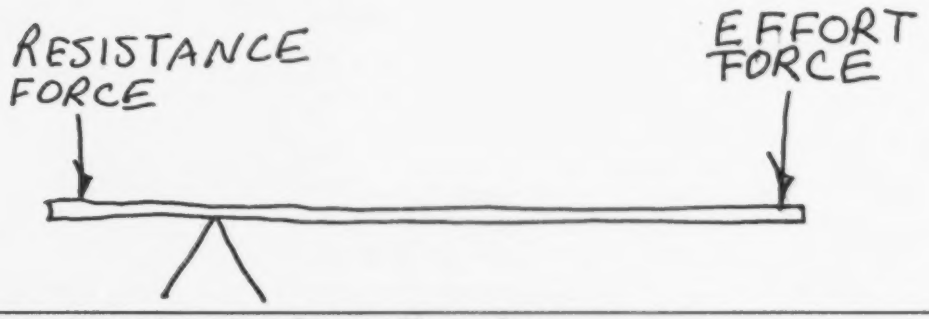

Figure 1. Example of a First Class Lever.

in now seemingly ancient warfare, that rocks, burning tar balls and the like were thrust over the walls of an enemy castle, moat and so on (see Figure 2).

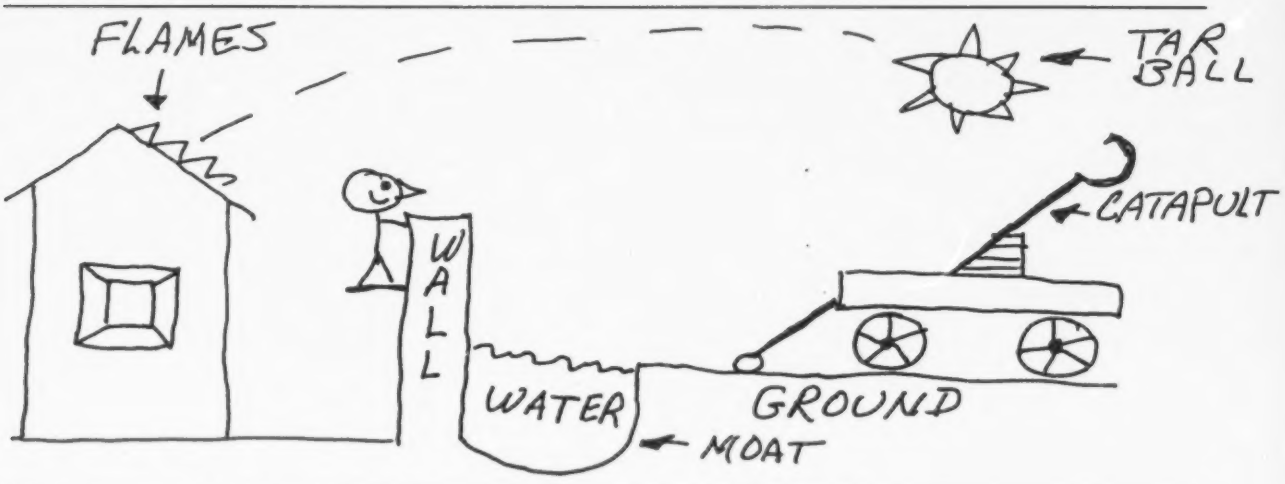

Figure 2. Example of a Catapult.

PRESENTATION

The teacher's objective in the activity is to lead students to identify launch angle, when other variables are controlled, as the variable controlling the distance a projectile will travel. In searching for the controlling factor, students: (a) participate in a hands-on activity; (b) work in research teams; (c) pool data; (d) build computer data bases and; (e) more. Teachers who conduct this activity should know how to construct, store, manipulate, and print an AppleWorks data base. Directions for constructing such data bases are packaged with the AppleWorks program.

Important to a catapult user was the factor which must be adjusted to alter the distance an object could be projected. Perhaps equally important was the question of whether or not two or more factors interacted to control the distance the projectile could be thrown. To adequately analyze this problem several factors must be examined. You can list them by examining Figure 3.

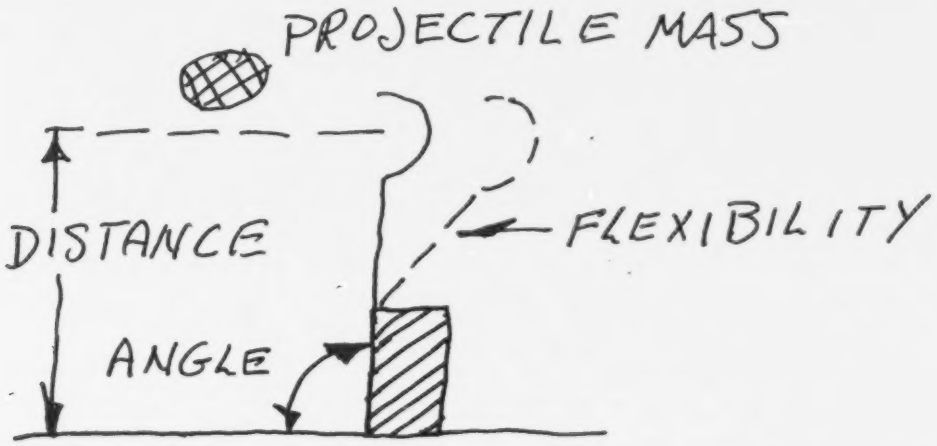

Figure 3. Schematic Diagram of a Catapult.

There appear to be several factors which might have an effect on the distance a projectile might travel when released by a catapult operator. Those readily evident from Figure 3 are the mass of the projectile, the distance from the ground of the projectile when it is released, the trajectory of the projectile, the flexibility of the catapult, the catapult release angle, the angle the catapult makes with the ground, and the catapult travel distance from the point where the catapult is released until the projectile is released.

Let's investigate trajectory, the path an object travels as it moves through the air (see Figure 4). Energy must be transferred to the projectile. That energy is expended as the projected object moves

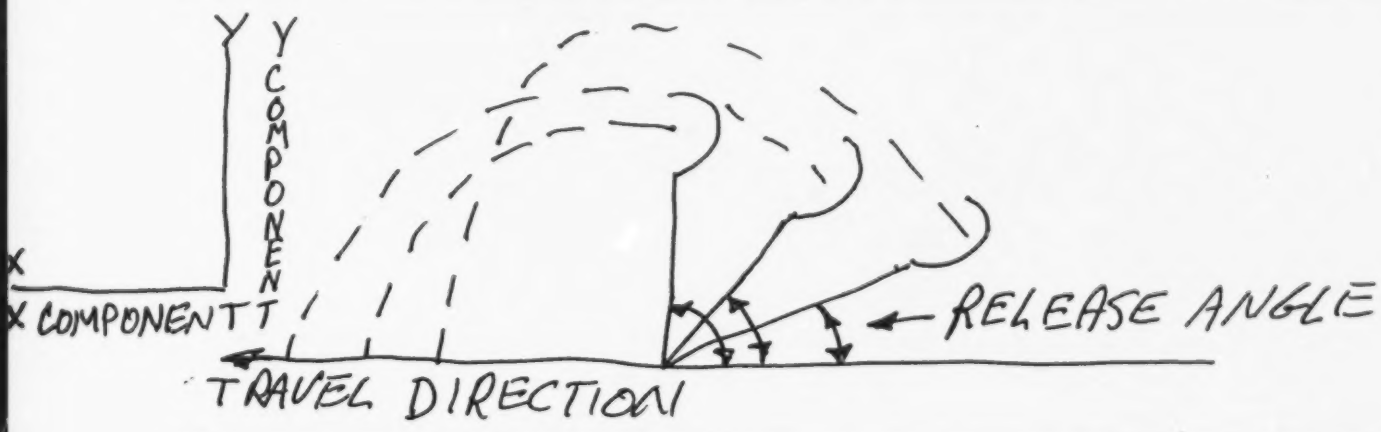

Figure 4. Example of Trajectories.

through the air counteracting the effect of gravity. The actual horizontal distance of projectile travel is a composite of vertical and horizontal travel. At launch angles near 0°, more energy is

expended moving an object in the vertical direction than in the horizontal direction. Launch angles may be established relative to a plane horizontal to earth surface or vertical to its surface. As long as you and your students agree in the beginning, the plane of relativity is unimportant. Objects launched at or near 90° expend most of their energy moving up in a horizontal direction. The optimum launch angle is that which propels a projectile a desired distance. That distance could be the greatest distance if a baseball player on the outfield needs to toss a fielded ball to home plate. The desired launch angle in the case of a mortar or artillery shell is that which will deliver the shell to the desired target. Extrapolating further the desired launch angle is 0° (opposite angle definition for that used above) with respect to its vertical orientation to earth's surface. Booster rockets provide only sufficient thrust to lift the launch vehicle into the desired orbit and gravity is partially overcome for some finite period.

Science Concept: The paths of all suborbital projectiles form parabolas.

Objective: Upon completion of this activity, students should be able to identify launch angle which with other factors controlled dictates the distance a projectile will be hurled from a launch vehicle.

Grade Levels: The activity can be used as low as grade 3 (perhaps lower) and on into college (especially in elementary science education programs). Users must alter the level of sophistication with which the activity is presented as the grade level increases.

Time Requirements: An initial period of 30-45 minutes must be allowed for the initial playing around and data gathering phase. The computer phase may be accomplished over a week or so by individual teams, making the activity usable in classes having only one Apple computer. The final data analysis and discussion periods require approximately 30 minutes. Again, the grade level determines the actual time requirements.

Partial List of Variables:
1. Launch Angle (see Figure 3).
2. Force with which the projectile is launched (elasticity of the spoon and the distance the spoon is drawn back before release).
3. Mass of the projectile.
4. Height from the ground that the projectile is launched.
5. Thickness of the spacer block (see Figure 5).

Science Skills:
1. Observing.
2. Data Collection.
3. Data Analysis.
4. Hypothesizing.

Math Skills:
1. Measuring
2. Counting.

Computer Skills:
1. Building databases.
2. Data Input.

3. Database file storage.
4. Database file manipulation.
5. Printing files.
6. Formatting data storage disks.

Vocabulary:

1. Catapult.
2. Projectile.
3. Mass.
4. Hypothesis.
5. Data base.
6. Data.
7. Analysis.
8. Launch.
9. Launch angle.

Materials: Unless otherwise noted, the materials listed are for research teams of two students each.

1. 1 marshmallow (gumdrop size).
2. 1 plastic picnic spoon.
3. 1 centimeter ruler (see Figure 5).
4. 1 pencil.
5. 3-4 sheets of 8 1/2" X 11" notebook paper to use for recording data.
6. 1 meter stick.
7. 1 roll of masking tape per class.
8. 1 protractor.
9. 1 piece of chalk 1.5 cm. long.
10. 1 spacer block approximately 3.5 cm. thick (see Figure 5 for additional details). The spacer may be of any available material but all blocks used by a class should be the same thickness. Using blocks of the same thickness will control this variable.
11. 1 triple arm or other type balance for every 10 students.
12. 1 Apple IIe or GS computer for each class (with printer).
13. 1 copy of the Appleworks program for each class (Versions 1.3, 2.0, 2.1 or 3.0 may be used).
14. 1 data storage disk for every 10 students.

Procedures:

1. Research Teams. Divide the class into research teams of two students each and give each team a number. Team numbers will be used when students pool data and build a computer data base file.
2. Catapult Construction.
   a. Give each team:
      (1) 1 ruler.
      (2) 1 spacer.
      (3) 1 short piece of chalk.
      (4) Masking tape should be available but will be shared by all students.
      (5) 1 plastic spoon.
   b. Each research team builds a catapult like the one shown in Figure 5. You may want to make an overhead projection of the catapult so it can be seen by each research team.

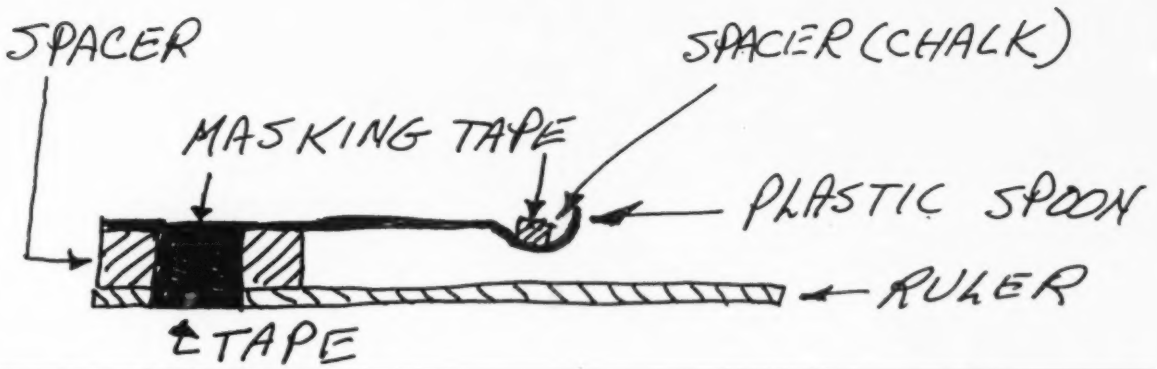

Figure 5. The Catapult.

3. Unguided Investigation.
   a. Give each team:
      (1) A meter stick.
      (2) One small marshmallow.

   b. Allow approximately 10 minutes during which research teams are encouraged to learn all they can about catapults using the tools they have.

4. Brainstorming. Conduct a session during which students are encouraged to discuss what they have found out about catapults. Also have them derive a list of items which are factors controlling the distance the catapult will hurl the projectile. List those factors on a chalkboard or a flip chart.

5. Experimental Design. Allow a period during which research teams are allowed to design an experiment to test the variables identified during the brainstorming session.

6. Research Design Discussion. Have the class discuss their research designs.

7. Data Collection Table. Lead the students to develop a data collection table. An example of such a table is shown in Figure 6.

Team	No. Trial	Mass	Angle	Tvl Dist.
1	1			
1	2			
1	3			
1	4			
2	1			
2	2			

Figure 6. Example Data Gathering Table.

8. Data Collection. Allow a period for data collection. Encourage students to investigate a variety of different launch angles. Each team should be provided with a protractor. An alternative to using a protractor to determine launch angles is to provide each team with a premeasured strip like the one shown in Figure 7.

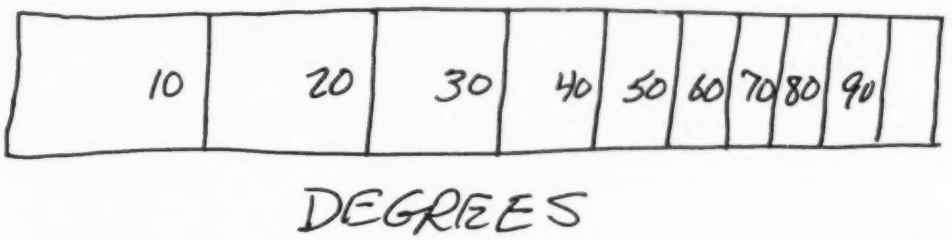

Figure 7. Example Premeasured Strip.

The paper strip is taped on a wall and the end of the ruler to which the spoon is attached is placed at the various degree markers and then the marshmallow is launched. Care should be taken to:

a. Check the angle with the protractor
b. The projectile is not being released from the catapult prior to the point where the plastic spoon is at the same launch angle as the ruler. Figure 8 shows the experimental setup.

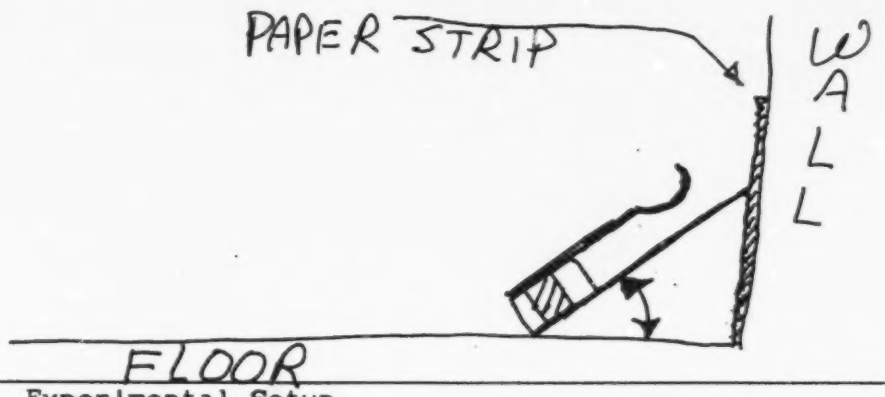

Figure 8. Experimental Setup.

9. Data Pooling. Allow a period where research teams pool data. After the session, all teams should have the data generated by all other teams.

10. Building A Computer Database.

    a. Each research team constructs their own AppleWorks database. There should be a record for each trial. An example database containing real data is shown in Figure 9.

TEAM NO	TRIAL NO	MASS	LAUNCH ANG	DIST (CM)
1	1		10	
1	2		20	
1	3		30	
1	4		40	
1	5		50	
1	6		60	

FIGURE 9. An Example of a Database Containing Real Data.

    b. Each team inputs all data collected by all teams.

11. Storing, Arranging, Finding and Printing.
    a. Store the file on a data disk by pressing the APPLE & S keys at the same time.
    b. Rearrange the database on the mass, launch angle and distance categories respectively from lowest to highest values by pressing the APPLE & A keys at the same time and using the directions provided on the screen.
    c. Examine each rearrangement for trends. Does projected distance increase or decrease naturally as launch angle changes, as mass changes?
    d. Find all trials of the same launch angle and compare them with launch distance. This is accomplished by pressing the

APPLE & F keys at the same time and following the directions provided on the monitor screen.

e. Print the various rearrangements. This is accomplished usingthe APPLE & P key sequence and following the screen directions (you will choose "creating a new table" when asked by the AppleWorks program menu to select a choice).

12. Examination Period. Allow a period for researchers to examine their computer printouts.

13. Discussion Period. Lead a class discussion where students are allowed the opplortunity to describe their findings. You may want to have teachers put their results on a chalkboard so they may be easily compared. Overhead projections could be made and the results projected.

Curriculum Extensions:

1. Conduct the project a second time using M & M's as the projectile. Compare the results of the two activities.
2. Conduct the original activity a second time, using longer plastic spoons or thicker spacers at the base of the spoon. Compare the results of the two activities.
3. Conduct a library report project where students have to research the way mortar tubes or artillery pieces function. What similarities are found between the results of the original project and the findings of the library project?
4. Lauch projectiles from a specific angle while at the same time dropping a projectile of the same mass from the same height. Which one hits the floor first?

Summary

Coming to know or understand why the world functions as it does requires observation. The observations, however, must be controlled. It is the controlling of observations through the manipulation of data that we understand to be one of the processes of science, so very important to our precepts of everything we do. Students who participate in this activity practice using that process. The activity is open ended. All possible variables are not investigated. Some like spacer thickness is controlled, thus the subject of extended research, but that's how research is. The results of each investigation provides another link in our chain of understanding.